

EVAPOTRANSPIRATION AS A REGIONAL CLIMATE PRIORITY: RESULTS FROM A NASA/USDA WORKSHOP

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On April 5 to 7, 2011, the National Aeronautics and Space Administration (NASA) and the United States Department of Agriculture-Agricultural Research Service (USDA-ARS) sponsored a Workshop on Evapotranspiration (ET) in Silver Spring Maryland. The workshop was a response to a recommendation in the 2009-2011 GEO (Group on Earth Observations) Work Plan that a workshop on ET should be held to discuss issues related to ET products and services and the potential for incorporating ET activities into the 2012-2015 GEO Work Plan. The workshop had a regional emphasis, although there were several excellent international and global presentations including one on the GEWEX LANDFLUX project. The different scales of these activities suggests that a framework is needed that can accommodate both regional and global ET activities. Despite limitations with the workshop's scheduling, it attracted 76 experts who contributed informative presentations and insightful discussions.

The goals of the workshop involved the exchange of information and ideas and the development of plans for providing more visibility for ET issues. Specific objectives included 1) defining the needs and requirements for evapotranspiration data in weather and climate studies, in natural and agro-ecosystem monitoring, and in water resource management; 2) reviewing the methods used to measure and model evapotranspiration; 3) assessing surface and satellite observation systems required to support ET measurement, modeling and evaluation; 4) assessing the feasibility of developing a proposal for a task on evapotranspiration for the 2012-2015 GEO Work Plan, and 5) exploring the level of support and consensus for developing a strategy for establishing evapotranspiration as an Essential Climate Variable (ECV) within the Global Climate Observing System (GCOS) framework

The workshop featured a combination of oral presentations and breakout group sessions focused on the above objectives. There were also poster presentations providing opportunities for one-on-one discussions of ET modeling and measurement techniques. Presentations by users of ET data set the tone for the workshop. In the USA at the national and regional levels water rights issues represent a major opportunity for ET applications. ET data play a major role in estimating water loss due to irrigation, the largest cause of consumptive water loss in the USA, particularly in the West. Irrigation requirements are relatively specific since the needs are clearly defined by the geometry and number of the irrigation systems and can be monitored with high resolution satellite data. There was a strong consensus that land surface temperature (LST) at high resolution is critical for monitoring irrigation. State governments have made commitments to more efficient water management in the western US, but they need full access to improved and more timely ET data and applications to implement this plan. Water managers also reported that in spite of the recent development of new techniques, the procedures used in some of the water balance calculations in some states are out of date and do not take advantage of new observational and data assimilation systems. The development of ET forecasts for water management is also seen as a priority. Although ET forecasts are currently being produced on an experimental basis these predictions could be improved by considering ET as a dynamic prediction variable in models and by increasing the time resolution of these ET predictions.

ET data are also required for international applications. The famine warnings distributed through FEWSNET in Africa rely on accurate ET estimates. In some cases, the estimates of ET are critical for water budget computations and the management of transboundary basins. In the case of transboundary basins shared by countries that are unwilling to exchange data, global ET products could have substantial benefits. In addition, the climate modeling community has a need for reliable ET data on a global basis to validate GCM estimates. However, at present, there are no long-term homogenous ET data sets suitable for evaluating the trends of ET estimated by models. Through its NEWS program, NASA is developing data sets for closing water budgets over the land areas of the globe. The workshop was challenged to see how it could contribute to the estimation of ET globally using techniques and observational systems that have been developed for regional issues.

The review of existing observational systems for meeting user needs identified deficiencies in the current system. At present, the large uncertainties in flux measurements, primarily using the eddy covariance (EC) technique, are addressed through extensive post-processing. These requirements make it difficult to move EC flux measurements from the research arena to the operational domain. In terms of *in-situ* systems there are a range of instruments available for measuring ET. However, other than FLUXNET which employs EC technique, it does not appear that other measurement systems have been coordinated in a network. Scintillometry offers a source of observations that may provide reliable ET for cal/val and model development activities at larger spatial resolutions than FLUXNET. NEON is an exciting US opportunity that will provide more ET data and a plethora of ancillary information on vegetation, soil and ecosystem services. Efforts should be made to integrate NEON measurements into FLUXNET plans. Some FLUXNET towers have had a long-standing problem in closing the energy budget although recent findings presented at this workshop suggested this problem was largely the result of under measurement of the vertical velocity and soil heat flux. The various FLUXNET programs around the world could constitute a candidate reference network for ET measurements if the flux towers had a more uniform distribution over the Earth's land surface and followed more comprehensive observational protocols.

Satellites provide measurements that are critical boundary conditions for estimating ET on spatially uniform grids at different resolutions for the Earth's land areas. Thermal observations providing LST are deemed essential for developing robust techniques in quantifying ET because LST is fundamentally coupled to the energy state of the land surface. Although cloud cover prohibits continuous coverage of LST over the globe, creative data processing techniques can maximize the information value of these observations. For example, it was shown that high resolution products at finer time scales can be produced with good interpolation schemes that fuse infrequent high resolution data with more frequent moderate to coarse resolution data. New satellites such as the Geostationary Operational Environmental Satellite (GOES) -R combined with other geostationary satellites (e.g., METEOSAT) covering other continents will provide new opportunities to obtain global estimates of ET. In addition, microwave sensors such as the future Soil Moisture Active Passive (SMAP) satellite also will provide a new ET product that may be very useful in the development of a continuous product since clouds do not obscure microwave observations of the land surface. There is a role for the science community to assist in developing and testing new products as data from these satellites come on line.

The modeling community also needs support to develop better ET parameterizations and products. Evidence was presented showing that major differences in ET estimates occur when different sources of radiation data are used. These sensitivities highlight the importance of having access to high quality and relevant data sets as inputs for ET calculations. Furthermore there are many different methodologies and parameterizations developed for computing ET in prognostic (e.g., numerical weather prediction models) and diagnostic (remote sensing-based models) models. There are also significant uncertainties

in key inputs to prognostic models (e.g., precipitation) as well as diagnostic models (e.g., LST). However evidence was presented showing that for remote sensing-based approaches using LST, it is possible to significantly reduce uncertainty in ET computations due to errors in LST by defining wet and dry ET extremes and associated LST values to internally calibrate model parameterizations for a given satellite scene or to use a time-differencing approach with geostationary satellite-derived LST observations coupled to a land-atmosphere model of morning boundary layer growth.

A significant outcome of the workshop is the decision to generate two white papers by the Fall of 2011. One paper will focus on the benefits and applications of routine ET observations in the user community. The second paper, will be a State-of-the-Art review of measurement and modeling of ET and serve as the basis for a scientific journal article. In addition, a document will be derived providing specific criteria for a Global Climate Observing System (GCOS) Essential Climate Variable (ECV) and a short proposal for incorporating ET as a ECV in the GCOS implementation plan will be developed. If deemed appropriate, a small list of activities will be developed for consideration in the 2012-2015 GEO work plan. Consideration will also be given to holding several follow-on ET workshops: one in conjunction with users, primarily in the western U.S., a second in Europe to engage the broader international community on the efforts initiated from the Silver Spring meeting and a third in conjunction with the GEWEX LANDFLUX project to ensure these regional/continental activities are mutually supportive with their global initiative. The science community also needs to ensure that it takes advantage of the interest of U.S. and international water resource agencies concerned with water availability for competing needs such as crop production, human consumption, energy production and ecosystem services. These agencies need access to ET databases and decision support tools to address these issues. They also have requirements for continuity and reliability in the products that they use. In addition, they should be able to demonstrate in concrete terms the benefits of Earth Observations for decision making purposes. To this end, consideration is being given to establishing a Working Group to discuss ET data needs, to promote the development of ET databases, and to address ET issues.